Financial Effects of Health Information Technology: A Systematic Review

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Background: Health information technology (HIT) is widely viewed as an important lever with which to improve the quality and efficiency of the healthcare system. However, there has long been debate about its financial effects.

Objectives: To characterize the existing data on the financial effects of HIT and to consider the implications for the effect of HIT on healthcare spending.

Study Design: Systematic literature review.

Methods: We identified articles by (1) searching PubMed using the intersection of terms related to HIT applications and terms related to financial or economic effect; and (2) reviewing the reference lists of the included articles as well as additional policy articles and literature reviews.

Results: A total of 57 articles met our inclusion criteria, including 43 articles (75%) reporting financial benefits to a stakeholder associated with HIT. These included 26 articles (46%) reporting cost savings, 6 articles (11%) reporting revenue gains, and 11 articles (19%) reporting a mixture of cost savings and revenue gains. Among articles with experimental study designs, 22 of 34 (65%) reported financial benefits; and among articles explicitly measuring costs and benefits, 19 of 21 (90%) reported financial benefits. The most prevalent mechanisms were savings on administrative goods and/or personnel, savings on pharmaceuticals, and revenue gains through improved billing. Overall there is a dearth of articles on this topic, especially ones with strong study designs and financial analyses.

Conclusions: HIT can have financial benefits, but more research is required, especially on HIT's effects under emerging delivery and payment reform efforts.

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Health information technology (HIT) is an important lever with which to improve the quality and efficiency of the healthcare system.[1,2] The federal government's belief in the importance of HIT motivated a commitment of up to $30 billion in funding for HIT as part of the Medicare and Medicaid Electronic Health Record (EHR) Incentive Program and related efforts through the American Recovery and Reinvestment Act of 2009.[3]

Despite the promise of HIT, there has long been debate about its financial effects, both on individual providers and payers on the microeconomic level and on the US healthcare system at the macroeconomic level.[4,5] This question has become especially significant given the great interest within the healthcare industry and among policy makers in finding ways to control growing healthcare costs. State and federal governments are the nation's largest healthcare payers and have invested heavily in HIT. As a result, they have a strong interest in understanding its financial effects.

To date, several groups of researchers have reviewed the literature to understand the quality and efficiency effects of HIT in general or of specific types of HIT, including EHRs, computerized physician order entry (CPOE), and clinical decision support (CDS).[5-13] Notably, Chaudhry and colleagues conducted a systematic review of articles published between 1995 and January 2004 to assess the effects of HIT on quality, efficiency, and cost.[6] Two subsequent reviews, conducted by Goldzweig and colleagues[8] (June 2004 to June 2007) and Buntin and colleagues[13] (July 2007 to February 2010), updated that research, though each explored new themes. In 2008, the Congressional Budget Office assessed evidence on the costs and benefits of HIT to offer guidance for the federal government's HIT strategy.[5]

Although several of the above articles explored HIT's effect on cost, none compiled data on the financial effects of HIT in a systematic way. In at least 2 cases the authors cited a paucity of articles addressing HIT's effect on costs.[6,8] In addition, previous articles have not compared the financial effects and their mechanisms across different types of clinical settings and technologies. We systematically reviewed the literature to characterize the existing data on the financial effects of HIT and considered the implications for HIT's effect on healthcare spending.

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Take-Away Points

Although health information technology (HIT) interventions are associated with financial effects, including cost savings and revenue gains, there are few articles on this topic, especially ones with strong study designs and financial analyses.

- Benefits are consistent across different settings and technologies.
- Prevalent mechanisms for financial effects include savings on administrative goods and/or personnel, savings on pharmaceuticals, and revenue gains through improved billing.
- Among articles reporting financial benefits, providers benefited in a majority of them, and payers in a minority of them.
- It is unclear from current evidence whether HIT on its own can reduce general healthcare spending.

METHODS

Inclusion Criteria

We limited our review to articles investigating the effects of 4 types of HIT applications used by healthcare providers in the delivery of care: EHRs, CPOE, CDS, and health information exchange (HIE). These applications were chosen because they have been the subject of the bulk of the debate about the potential beneficial effects of HIT and are central to the meaningful use criteria for the Medicare and Medicaid EHR Incentive Program. We used well-established definitions for EHR, CPOE, and CDS, most notably documented in an article by Blumenthal and colleagues on HIT.[14] We defined HIE as systems or applications that connect HIT systems maintained by separate healthcare providers, payers, and other stakeholders, thus allowing providers to share electronic information about common patients.

In addition, our inclusion criteria required that studies (1) explore a financial effect as a principal outcome measure (alone or in combination with other outcomes); (2) quantify the effect in monetary terms for 1 or more stakeholders (articles reporting other related measures, such as length of stay or other types of utilization, were excluded unless the effect was explicitly measured in monetary terms); (3) present primary research rather than a compilation or review of existing literature; (4) be published in an English-language, peer-reviewed journal since 2000; and (5) be set in the United States, since we reasoned that the unique characteristics of this country's healthcare system—specifically those impacting the financing, adoption, and use of HIT systems—would render foreign studies' findings less relevant to our objectives. Finally, in the event authors had written more than 1 qualifying study on the effect of the same HIT application on a similar setting or population, we included only the most recent article.

Study Identification and Selection

Our search for candidate articles consisted of 2 phases. In the first phase, we searched PubMed in February 2012, using the intersection of 2 lists of search terms: the first related to HIT applications and the second related to financial or economic effects (**eAppendix A**, available at **www.ajmc.com**). In the second phase, we identified other relevant studies by reviewing the reference lists of the included articles as well as additional policy articles and literature reviews.

Data Definitions

The team developed a list of data items to be extracted from the articles (**eAppendix B**, available at **www.ajmc.com**). Key data fields included the following:

Health Information Technology Application. We documented the primary HIT application under investigation: EHR, CPOE, CDS, HIE, or multiple. Because nearly all CPOE applications in the literature included CDS and because most CDS applications were part of a CPOE application, we merged those 2 categories into 1 category. Otherwise, when an article included more than 1 of these applications, we assigned the article a single designation based on the emphasis of the article.

Clinical Setting. We documented the primary clinical setting for the study. These included: emergency department (ED), inpatient, outpatient, or multiple.

Study Design Classification. We classified each study according to its design. A rating of 1 indicated experimental studies, including randomized controlled trials. A rating of 2 indicated observational studies with concurrent control groups. A rating of 3 indicated observational studies with historical controls. A rating of 4 was given to case studies, case series, or other reports in which no control group was included or experimental design described. A rating of 5 was assigned to quantitative simulations where outcomes were modeled based on inputs such as literature review, expert analysis, and projections.

Financial Outcomes. We categorized the studies' financial outcomes as follows: (1) there was a positive effect for the stakeholder(s) of interest in the study; (2) there was a neutral or mixed effect for the stakeholder(s); or (3) there was a negative effect for the stakeholder(s). In addition, we classified each study according to whether or not it documented the costs of the HIT intervention to stakeholders as well as the benefits.

Stakeholder Perspective. Finally, we documented to which stakeholder(s) the financial benefit or loss accrued. The 4 stakeholder categories were (1) provider, (2) payer, (3) consumer, and (4) the community, society, or health system at large. It was not always clearly stated which stakeholder

accrued the benefit or loss, so in those instances we used our best judgment.

Data Extraction

Three different team members, including 2 health services researchers and a policy analyst, were responsible for reviewing and extracting the data items from each article. All extracted data were discussed and discrepancies were resolved through consensus.

Data Analysis

We calculated counts and percentages for each category of interest and graphed the principal outcomes for all articles meeting our inclusion criteria. We also conducted 2 sensitivity analyses. In the first sensitivity analysis, we assessed whether our results would differ if we included only articles with study design ratings of 1, 2, or 3 (experimental studies or observational studies with concurrent or retrospective controls), because those studies might be considered more reliable than the others. In the second sensitivity analysis, we assessed whether our results would differ if we included only articles that documented both the cost and benefit of the HIT intervention, because we considered this documentation to be indicative of at least a basic rigor in the economic analysis.

RESULTS

We reviewed 4600 search results. Based on their abstracts, we selected 96 (2%) for full-text review and added 24 others that we identified from the bibliographies of other articles on this topic. Of these 120 articles, 57 articles (48%) met our inclusion criteria and were the basis for our analysis. (**eAppendix C**, available at **www.ajmc.com**).

Characteristics of the Included Studies

The 57 articles were very heterogeneous. For example, they ranged from studies of single CDS rules to multifunctional EHRs; from studies set in single solo or small practices to studies of the US healthcare system; from studies lasting a few months to those covering multiyear spans; and from studies where financial effects were the only outcome under investigation to those where the financial effect was one of several outcomes.

More than half (30/57, or 53%) of the articles investigated interventions solely in outpatient settings, while 17 articles (30%) focused on interventions in the inpatient setting, and 6 articles (11%) investigated interventions in the ED setting (**Table**). Twenty-six articles (46%) explored EHRs, 24 articles (42%) explored CPOE/CDS, and 5 articles (9%) investigated HIE.

Among the outpatient articles, there were 17 (57%) on EHRs and 13 (43%) on CPOE/CDS. Among the inpatient articles, 10 articles (59%) focused on CPOE/CDS. Among the ED articles, 4 (67%) investigated the effect of HIE.

A majority of the articles (34/57 or 60%) were either experimental studies or observational studies with concurrent or retrospective controls (ratings of 1, 2, or 3). A total of 11 articles (19%) were case studies (study rating of 4), and 12 articles (21%) were models or projections (study rating of 5) (Table).

Financial Effects of Health Information Technology

Three-fourths of the articles reported financial benefits for stakeholders (43/57 or 75%), while 10 articles (18%) reported a mixed or neutral effect, and 4 articles (7%) reported a negative effect (**Figure 1**). Cost savings were reported by 26 articles (46%), 6 articles (11%) reported revenue gains, and 11 articles (19%) reported a mixture of cost savings and revenue gains. Financial benefits were reported consistently across different types of setting (**Figure 2**) and different types of HIT applications (**Figure 3**). However, only a minority of articles (22/57 or 39%), including 20 of the 43 articles (47%) reporting benefits, included the costs of the intervention.

As described above, it was not always explicitly stated which stakeholders benefited from the HIT implementation. Among the 43 articles reporting positive financial outcomes, providers benefited, or appeared to benefit, in 32 articles (74%); payers benefited in 12 articles (28%); society benefited in 5 articles (12%); and consumers benefited in 1 article (2%).

Among 17 outpatient EHR articles, 14 (82%) reported positive financial outcomes, all of which benefited providers. Of the 13 outpatient CPOE articles, 9 (69%) reported financial benefits, 6 to payers, 3 to providers, 2 to society, and 1 to consumers. The 10 inpatient CPOE articles included 6 (60%) reporting positive financial outcomes, all to the benefit of providers. Among the 4 ED HIE articles, 3 (75%) reported positive financial outcomes, all benefiting payers and 1 that also benefited society.

We reviewed the articles to identify any trends among the identified mechanisms of the financial effects. The most widely cited mechanism of the financial benefits was savings on administrative goods and/or personnel (cited by 20 articles), which was mostly driven by outpatient EHRs (**Figure 4**). A total of 17 articles reported savings on pharmaceuticals, mostly associated with CPOE/CDS (both inpatient and outpatient setting). A total of 14 articles reported provider revenue gains from improved billing coding accuracy, again associated with outpatient EHRs; and 10 articles reported savings associated

Table. Types of Studies

Classification	No. (%) All Articles (N = 57)	Sensitivity Analysis 1: Articles Excluding Case Studies and Simulations (n = 34)	Sensitivity Analysis 2: Articles Reporting Both Costs and Benefits (n = 21)
Type of health information technology application			
CPOE/CDS	24 (42)	19 (56)	3 (14)
EHR	26 (46)	9 (26)	15 (71)
HIE	5 (9)	4 (12)	3 (14)
Multiple[a]	2 (4)	2 (6)	0 (0)
Study setting			
Emergency department	6 (11)	6 (18)	1 (5)
Inpatient	17 (30)	14 (41)	2 (10)
Outpatient	30 (53)	14 (41)	14 (67)
Multiple	4 (7)	0 (0)	4 (19)
Setting/application			
Emergency department HIE	4 (7)	4 (12)	1 (5)
Inpatient CPOE/CDS	10 (18)	8 (24)	2 (10)
Inpatient EHR	5 (9)	4 (12)	0 (0)
Outpatient CPOE/CDS	13 (23)	10 (29)	2 (10)
Outpatient EHR	17 (30)	4 (12)	12 (57)
Other	8 (14)	4 (12)	4 (19)
Study design			
Category 1: experimental	8 (14)	8 (24)	1 (5)
Category 2: observational with concurrent controls	10 (18)	10 (29)	2 (10)
Category 3: observational with historical controls	16 (28)	16 (47)	3 (14)
Category 4: case studies	11 (19)	NA	7 (33)
Category 5: simulations	12 (21)	NA	8 (38)

CDS indicates clinical decision support; CPOE, computerized physician order entry; EHR, electronic health record; HIE, health information exchange; NA, not applicable.
[a]Including articles with multiple applications and no single emphasis.

with reduced adverse drug events mostly attributable to CPOE/CDS (again inpatient and outpatient). Notably, only 5 articles investigated the effect of HIT on costs related to chronic conditions, and only 1 of those 5 articles described financial benefits.

Sensitivity Analysis: Articles With High Study Design Ratings

We conducted a sensitivity analysis to assess whether our results would differ if we included only articles with study design ratings of 1, 2, or 3. The 34 articles meeting the criteria for this analysis included a majority of the inpatient CPOE/CDS articles (8/10 or 80%), outpatient CPOE/CDS articles (10/13 or 77%), and ED HIE articles (4/4 or 100%), but only a minority of the outpatient EHR articles (4/17 or 24%) (Table). A majority of articles (22/34 or 65%) still reported financial benefits (Figure 1). That group included 15 articles (44%) reporting cost savings, 5 articles (15%) reporting revenue gains, and 2 articles (6%) reporting a mixture of cost savings and revenue gains. A majority of articles within each setting category continued to report financial benefits. The most prevalent mechanisms of financial effect in this sensitivity analysis were reductions in pharmaceutical costs (9/34 or 26%) and reductions in costs for general acute or emergent care (7/34 or 21%).

Figure 1. Financial Effect of Health Information Technology on Stakeholders in Reviewed Articles

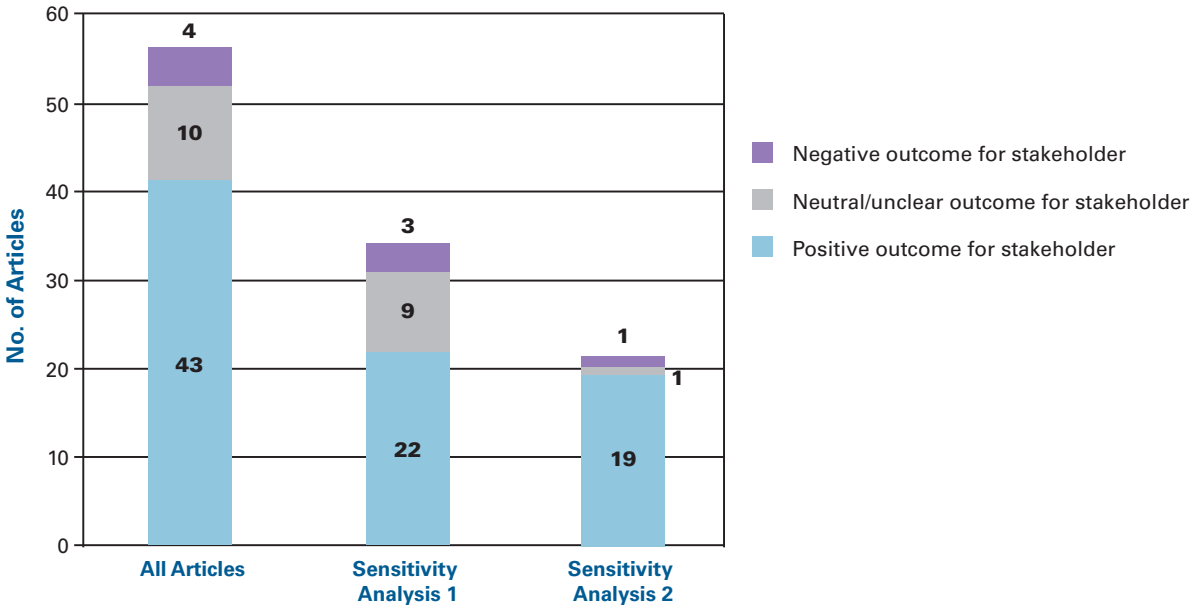
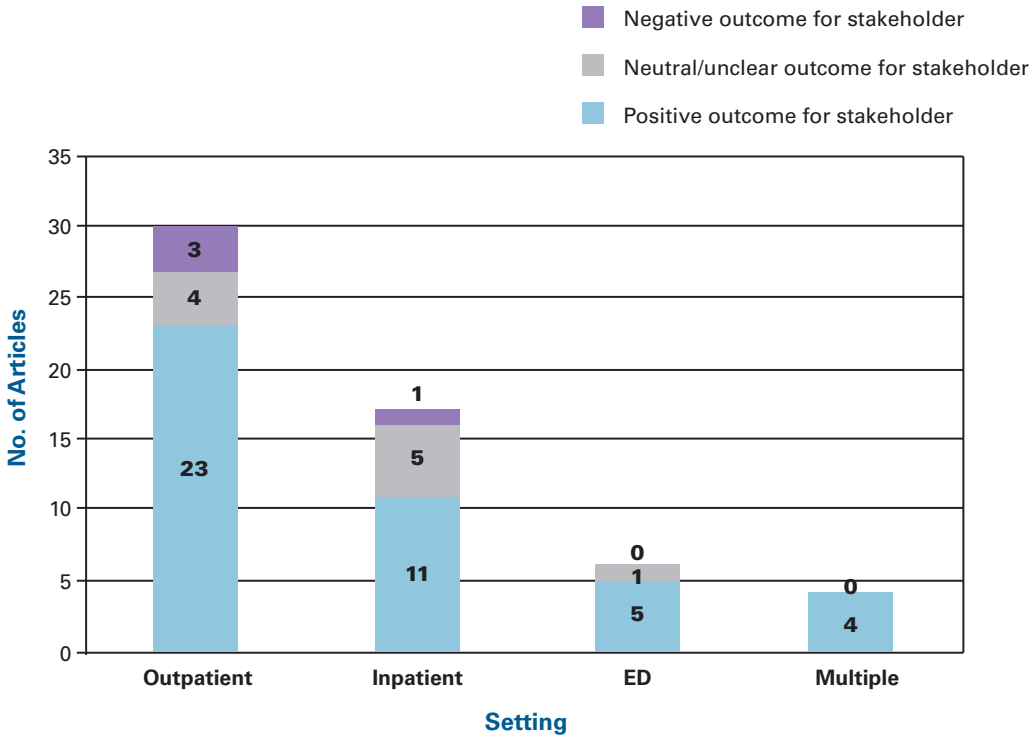
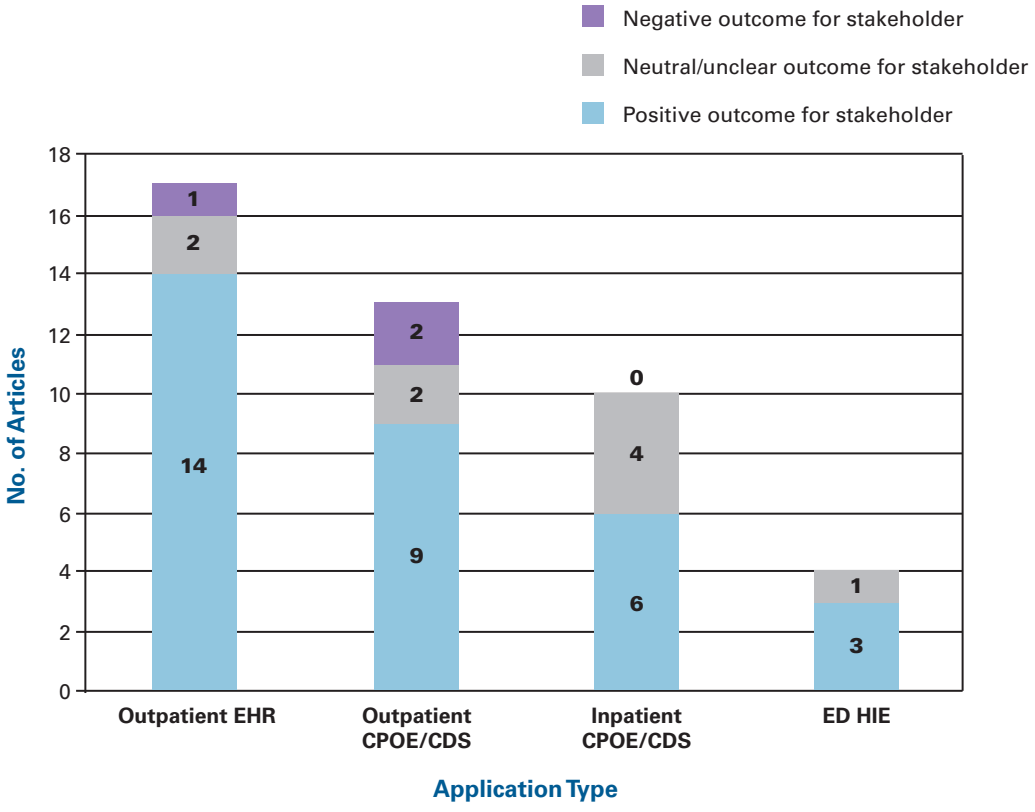


Figure 2. Financial Effect of Health Information Technology by Setting of Study



ED indicates emergency department.

Figure 3. Financial Effect of Health Information Technology by Application Type



CDS indicates clinical decision support; CPOE, computerized physician order entry; ED, emergency department; EHR, electronic health record; HIE, health information exchange.

Sensitivity Analysis: Articles Documenting Both Costs and Benefits

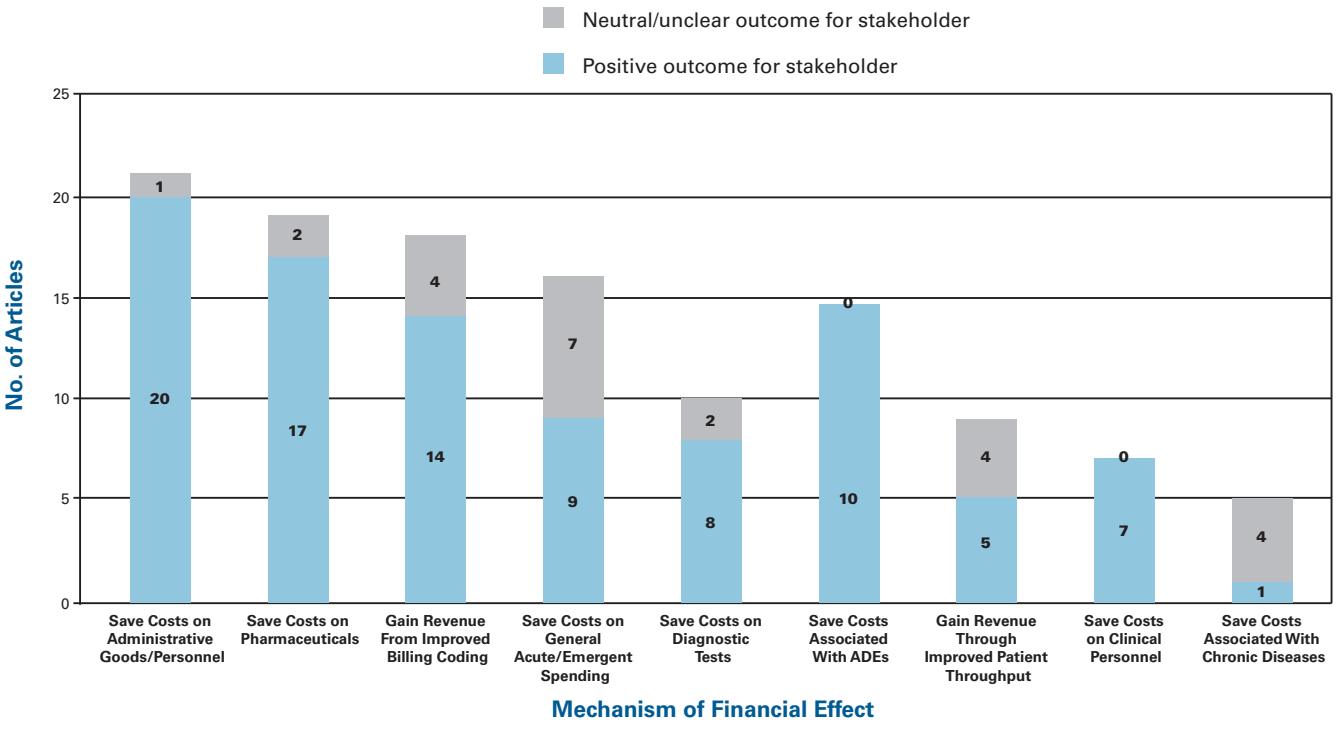
We conducted our second sensitivity analysis in which we included only articles with explicit costs and benefits. Twenty-one articles met the criteria for this analysis, including a majority of the articles on outpatient EHRs (12/17 or 71%), but a minority of the articles on outpatient CPOE/CDS (2/13 or 15%) and inpatient CPOE/CDS (2/10 or 20%) (Table). Compared with the original analysis, an even larger majority of articles (19/21 or 90%) reported financial benefits associated with HIT (Figure 1). Cost savings were reported by 10 articles (48%), 1 article (5%) reported revenue gains, and 8 articles (38%) reported both cost savings and revenue gains.

Notably, only 6 articles overall (11%) used both an experimental study design and reported costs and benefits, thus meeting the criteria for both sensitivity analyses. This group included 2 articles on outpatient EHRs, 1 article on outpatient CPOE/CDS, 2 articles on inpatient CPOE/CDS, and 1 article on ED HIE. All 6 resulted in positive financial outcomes, including 4 reporting cost savings, 1 reporting revenue gains, and 1 reporting both cost savings and revenue gains. Providers benefited in 5 articles (83%) and payers and society both benefited in the other article (17%).

DISCUSSION

The results of our literature review suggest that HIT interventions are associated with financial benefits including cost savings and revenue gains. The majority of articles (75%) reported financial benefits associated with HIT, and those benefits were consistent across different settings and technologies. However, the current evidence might be best characterized as "incomplete," because there was a general shortage of studies in this area. Among those articles that did merit inclusion, a large majority did not use either a rigorous study design or financial analysis. It is likely that publication bias played a significant role, limiting our ability to generalize based on available evidence. Few of the articles we found captured the full range of variables likely to be necessary to fully characterize and explain the financial effects of HIT.[15] In general, there is a need for more research in this area.

Figure 4. Mechanisms of Financial Effects



ADE indicates adverse drug event.

These findings are consistent with previous research. Goldzweig and colleagues[8] found a limited number of studies exploring the cost and cost-effectiveness effects of HIT. While there was "some empirical evidence to support the positive economic value of an EHR system," the authors noted that "projections of large cost savings assume levels of HIT adoption and interoperability that we are nowhere near achieving."[8] Buntin and colleagues[13] found that a large majority of the articles exploring efficiency outcomes had positive or mixed-positive results. However, they noted the limitations of publication bias.

Although it is too early to make reliable conclusions about the general effect of HIT, we can conclude that there is growing evidence that HIT applications can reap financial benefits for certain stakeholders when they are successfully deployed according to certain use cases. For example, outpatient providers have used EHRs to realize administrative savings and improve billing coding, and providers in inpatient and outpatient settings have used CPOE/CDS to reduce pharmaceutical costs. However, few studies have yet explored HIT's longitudinal effect on overall patient-level utilization, such as its effect on patients with chronic disease.[5]

The major policy question is to what extent the use of HIT can affect general healthcare spending. Based on the evidence here, it is difficult to draw any clear conclusions, especially from a small, heterogeneous group of articles. While a majority of articles reported cost savings of some nature, it should be noted that cost savings to specific stakeholders may not transfer to societal cost savings. Further, only a minority of the articles reported the cost of the HIT intervention, complicating efforts to assess the net economic effect. In addition, several articles reported revenue gains, which at best would have no immediate effect on spending and at worst might increase it. In all, a slim majority of articles reported cost savings alone or in excess of revenue gains. It should also be noted that most of the evidence for significant savings was based on national projections, whose conclusions have been faulted for being based on optimistic assumptions.[5]

Of course, many experts including HIT advocates have argued that HIT's potential will only be maximized through new payment and delivery models which encourage the use of HIT tools to better document, measure, and potentially impact the cost and quality of care.[16] At the time the results of this study were being written up, many providers and payers were testing new payment and delivery models, spurred in part by state and federal demonstration projects authorized by the Patient Protection and Affordable Care Act of 2010.[17] Meanwhile, the federal government is promoting HIT adoption and use through the EHR Incentive Program, and has often

cited HIT's importance to delivery reform.[13] Some research is emerging on the financial effects of these interventions. This is clearly an area that is ripe for research in the coming years.

As these types of payment and delivery models emerge, there clearly needs to be more primary research into the effect of HIT on healthcare spending. This research must take a holistic, objective look at the financial effects not only for providers but also for payers and society as a whole. In addition, there is a need for more research with a strong study design and strong financial analysis to give us more confidence in the findings. For example, few articles used rigorous financial analyses (eg, return on investment, net present value), considered competing investment opportunities, reviewed primary data over multiple years to allow for "lag effects," or even noted the providers' reimbursement methods. At a minimum, future articles should clearly state which stakeholders make the investment in the HIT application and enumerate the benefits or losses to that stakeholder and any other stakeholder likely to be impacted.[18]

Our study had several limitations. As noted above, it is likely that in some cases, investigators focused on only those outcomes which they anticipated might lead to positive results. In addition, few studies rigorously described their HIT systems, and those that did described heterogeneous applications even within the same HIT application category. It should also be noted that the success of an HIT system can depend on several environmental variables such as provider work flow, availability of support services, and the level of institutional HIT infrastructure and expertise. Some of our data depended on interpretation, most specifically the classification as to which stakeholder accrued the benefit or loss. Finally, we intentionally focused on financial outcomes, and thus omitted a body of research that investigated HIT's impact on other efficiency outcomes or other measures of value.[19]

In summary, this literature review suggests that there is growing evidence that HIT applications can realize financial benefits. However, more research is required, especially regarding HIT's effect on specific types of healthcare utilization and in concert with new delivery and payment models. In addition, future research needs to assess costs and benefits from societal, payers', and/or patients' perspectives.

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■ **eAppendix A.** List of Search Terms

HIT Intervention
Computerized Physician/Provider/Practitioner Order Entry/CPOE
Computerized Order Entry
Electronic Order Entry
Electronic Medical Record
Electronic Health Record/EHR
Electronic Prescribing/E-prescribing
Health Information Technology
Computerized Decision Support/CDS/CDSS
Computer/Computerized Reminders
Computer/Computerized Guidelines
Computer/Computerized Alerts
Electronic Referral(s)
Clinical Information System(s)
Automated Medical/Health Record
Automated Decision Support
Automated Reminders
Automated Guidelines
Automated Alerts
Electronic Patient Record
Computerized Patient Record
Clinical Data Repository/CDR
Payer/Payor Based Health Record/Payer-/Payor-
Health information exchange
Clinical data exchange
Regional health information organization/RHIO
Economic Outcome
Return on Investment/ROI

Cost-Benefit
Cost-Effectiveness/Cost-Effective
Cost Savings/Savings
Efficiency
Net Present Value/NPV
Financial Return(s)
Financial Gain(s)
Financial Analysis
Financial Effect/Impact
Financial Benefit(s)
Economic Return(s)
Economic Gain(s)
Economic Analysis
Economic Effect/Impact
Economic Benefit(s)
Redundant
Readmission
Productivity
Length of Stay/LOS/ALOS
Generics
Per Member Per Month/PMPM
Resources
Billing
Coding
Charges

■ **eAppendix B.** List of Data Items Extracted From Articles:

- Author(s)/Journal/Publication Year
- Study Year(s)
- Duration Between Implementation and Start of Data Collection
- Study Design (Detail)
- Study Design (Rating)
- Study's Adherence to Published Standards for Economic Analyses
- Type of Financial Effect Measure
- HIT Application (Category)
- HIT Application (Detail)
- Is the HIT Application Homegrown or Commercial?
- Study Institution's Experience with HIT
- Clinical Setting
- Setting Size
- Setting Characteristics (Clinical Specialty, Academic/Non Academic; Associated with a Healthcare System or Not)
- Is the Study Set at a "Benchmark" Institution?
- Sample Size
- Financial Outcome (Effect on Stakeholders in Study)
- Financial Outcome (Details)
- The Stakeholder(s) to Which the Benefit or Loss Accrued
- Did the Financial Outcome include a Cost Saving?
- Did the Financial Outcome include a Revenue Gain?
- Cost/Revenue Mechanism
- Other Results
- Limitations

■ **eAppendix C.** Evidence Table: Included Articles: Key Data Extracted

Author(s)/ Journal/ Publication Yr	Clinical Setting	HIT Application	Study Design	Financial Outcome[1]	Stakeholders to Whom Benefit (Loss) Accrues
Venkat, Chan-Tompkins, Hegde et al., Vaccine, 2010[1]	ED	CPOE/CDS	3	Positive	Provider
Stokes-Buzzelli, Peltzer-Jones, Martin et al., West J Emerg Med, 2010[2]	ED	EHR	3	Positive	Payer
Daniel, Ewen, Willey et al., Academic Emergency Medicine, 2010[3]	ED	HIE	3	Positive	Payer
Frisse, Johnson, Nian et al., JAMIA, 2011[4]	ED	HIE	2	Positive	Payer, Society
Overhage, Dexter, Perkins et al. Annals of Emergency Medicine, 2002[5]	ED	HIE	1	Neutral	N/A
Tzeel, Lawnicki, Pemble, Am Health Drug Benefits, 2011[6]	ED	HIE	2	Positive	Payer

Anderson, Jay, Anderson et al. JAMIA, 2002[7]	Inpatient	CPOE/CDS	5	Positive	Provider
Bogucki, Jacobs, Hingle et al., JAMIA, 2004[8]	Inpatient	CPOE/CDS	3	Positive	Provider
Chertow, Lee, Kuperman et al., JAMA, 2001[9]	Inpatient	CPOE/CDS	1	Neutral	N/A
Kaushal, Jha, Franz et al., JAMIA, 2006[10]	Inpatient	CPOE/CDS	2	Positive	Provider
McGregor, Weekes, Forrest et al., JAMIA, 2006[11]	Inpatient	CPOE/CDS	1	Positive	Provider
Mekhjian, Kumar, Kuehn et al., JAMIA, 2002[12]	Inpatient	CPOE/CDS	3	Neutral	N/A
Mullett, Evans, Christenson et al., Pediatrics, 2001[13]	Inpatient	CPOE/CDS	3	Neutral	N/A
Perez, Winters, Gajic, Am J Hematol, 2007[14]	Inpatient	CPOE/CDS	3	Positive	Provider
Taylor, Manzo, Sinnett, Healthcare Fin Mgt 2002[15]	Inpatient	CPOE/CDS	4	Positive	Provider
Teufel, Kazley, Basco, J Med Syst, 2011[16]	Inpatient	CPOE/CDS	3	Neutral	N/A

Deckelbaum, Feinstein, Schulman et al., J Trauma 2009[17]	Inpatient	EHR	3	Positive	Provider
Furukawa, Raghu, Shao, Health Services Research, 2010[18]	Inpatient	EHR	2	Negative	(Provider)
Hensing, Dahlen, Warden, et al., Healthcare Financial Management, 2008[19]	Inpatient	EHR	2	Positive	Provider
Thompson, Classen, Haug, JHIM, 2007[20]	Inpatient	EHR	5	Positive	Provider
Zlabeck, Wickus, Mathiason, JAMIA, 2011[21]	Inpatient	EHR	3	Positive	Provider
Amarasingham, Plantinga, Diener-West et al., Arch Intern Med, 2009[22]	Inpatient	Multiple	2	Positive	Provider
Himmelstein, Wright, Woolhander, Am J Med, 2009[23]	Inpatient	Multiple	3	Neutral	N/A
Apkon, Mattera, Lin et al, Arch Intern	Outpatient	CPOE/CDS	1	Negative	(Payer)

Med, 2005[24]					
Bu, Pan, Walker et al., Diabetes Care, 2007[25]	Outpatient	CPOE/CDS	5	Positive	Society
Fischer, Vogeli, Stedman et al., Arch Intern Med, 2008[26]	Outpatient	CPOE/CDS	2	Positive	Payer
Hunt, Siemienczuk, Gillanders et. al, Informatics in Primary Care, 2009[27]	Outpatient	CPOE/CDS	3	Positive	Provider
Johnston, Pan, Walker, Journal of Healthcare Info Mgt, 2004[28]	Outpatient	CPOE/CDS	5	Positive	Provider, Payer, Society
Kheterpal, Gupta, Blum et. al., Anesth Analg, 2007[29]	Outpatient	CPOE/CDS	1	Positive	Provider
Kinney, Otolaryngology - Head and Neck Surgery, 2003[30]	Outpatient	CPOE/CDS	3	Positive	Payer
McMullin, Lonergan, Rynearson, Journal of Managed Care Pharmacy,	Outpatient	CPOE/CDS	2	Positive	Payer

2005[31]					
Murray, Harris, Overhage et al., Pharmacotherapy, 2004[32]	Outpatient	CPOE/CDS	1	Neutral	N/A
Tierney, Overhage, Murray et al., Health Services Research, 2005[33]	Outpatient	CPOE/CDS	1	Negative	(Payer)
Tierney, Overhage, Murrary et al., J Gen Intern Med, 2003[34]	Outpatient	CPOE/CDS	1	Neutral	N/A
Weingart, Simchowitz, Padolsky et al, Arch Intern Med, 2009[35]	Outpatient	CPOE/CDS	5	Positive	Payer
Wells, Lobel, Dickerson, American Journal of Medical Quality, 2003[36]	Outpatient	CPOE/CDS	3	Positive	Payer, Consumer
Badger, Bosch, Toteja, Journal of Healthcare Information Management,	Outpatient	EHR	4	Positive	Provider

2005[37]					
Barlow, Johnson, Steck, Journal of Healthcare Information Management, 2004[38]	Outpatient	EHR	4	Positive	Provider
Baron, Fabens, Schiffman et al, Ann Intern Med, 2005[39]	Outpatient	EHR	4	Neutral	N/A
Block, Family Practice Mgt, 2008[40]	Outpatient	EHR	4	Positive	Provider
Cheriff, Kapur, Qiu et al., Intl Journal Med Informatics, 2010[41]	Outpatient	EHR	2	Positive	Provider
Cooper, Journal of Healthcare Information Management, 2004[42]	Outpatient	EHR	4	Positive	Provider
Grieger, Cohen, Krusch, Journal of the American College of Surgeons, 2007[43]	Outpatient	EHR	3	Positive	Provider

Kumar, Bauer, Journal of Revenue and Pricing Management, 2011[44]	Outpatient	EHR	5	Positive	Provider
McIntyre, Orthop Clin N Am, 2008[45]	Outpatient	EHR	4	Positive	Provider
Miller, West, Brown et al., Health Affairs, 2005[46]	Outpatient	EHR	4	Positive	Provider
Miller, West, Health Affairs, 2007[47]	Outpatient	EHR	4	Negative	(Provider)
O'Neill, Klepack, Journal of Medical Systems, 2007[48]	Outpatient	EHR	4	Positive	Provider
Patil, Puri, Gonzalez, Urology, 2008[49]	Outpatient	EHR	3	Positive	Provider
Simon, Simon, Int J Electronic Healthcare 2006[50]	Outpatient	EHR	5	Positive	Provider
Wang, Middleton, Prosser et al., Am J Med, 2003[51]	Outpatient	EHR	5	Positive	Provider
Welch, Bazarko, Ritten et al., JAMIA,	Outpatient	EHR	2	Neutral	N/A

2007[52]					
Zaroukian, Sierra, Journal of Healthcare Information Management, 2006[53]	Outpatient	EHR	4	Positive	Provider
Byrne, Mercincavage, Pan et al, Health Affairs, 2010[54]	Multiple	EHR	5	Positive	Provider, Payer
Hillestad, Bigelow, Bower et al., Health Affairs, 2005[55]	Multiple	EHR	5	Positive	Society
Schmitt, Wofford, Healthcare Financial Management, 2002[56]	Multiple	EHR	5	Positive	Provider
Walker, Pan, Johnston, Adler-Milstein et al., Health Affairs, 2005[57]	Multiple	HIE	5	Positive	Provider, Payer, Society

[1]Key for study's financial outcome:

- Positive: there was a positive effect for the stakeholder(s) of interest in the study.
- Neutral: there was a neutral or mixed effect for the stakeholder(s).
- Negative: there was a negative effect for the stakeholder(s).

■ ARTICLES REVIEWED

1. Venkat A, Chan-Tompkins NH, Hegde GG, Chuirazzi DM, Hunter R, Szczesiul JM. Feasibility of integrating a clinical decision support tool into an existing computerized physician order entry system to increase seasonal influenza vaccination in the emergency department. Vaccine. 2010;28:6058-6064.

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